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NATIONAL CANNERS ASSOCIATION
RESEARCH LABORATORY

PROCESSES FOR LOW-ACID CANNED FOODS IN METAL CONTAINERS

BULLETIN 26-L
Eighth Edition

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WASHINGTON, D. C.
December, 1955

REF

IMPORTANT POINTS FOR CANNERS

1. ***Follow approved procedures.*** The procedures given in this bulletin are based on sound theory and wide practical experience. For safe processing it is important that they be carefully followed.

2. ***Keep your key men informed.*** Irregularities in cook room procedure, such as unprocessed cans getting into the warehouse, inadequate venting of retorts during coming-up period, and using a wrong process, will occur unless the cook room is properly supervised. Insist that all supervisory personnel and retort operators read this booklet and understand the significance of the tasks they perform.

3. ***Equip your retorts properly.*** Tested and properly installed retort instruments are essential. Instruments need periodic testing.

4. ***Don't reduce processes.*** Processes in this bulletin give the highest quality consistent with safety.

5. ***Code your cans.*** The time period during which each code lot is packed should be as short as practicable—in no case longer than one day.

6. ***Keep your factory clean.*** High bacterial contamination may lead to spoilage. See Appendix.

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PROCESSES FOR LOW-ACID CANNED FOODS IN METAL CONTAINERS

INTRODUCTION

ON JANUARY 18, 1930, the Board of Directors of the National Canners Association approved for publication the processes suggested for various low-acid foods packed in metal containers. It was anticipated that further experimental work on processes for these foods, changes in the style of pack, and the advent of new products would necessitate revision of the publication at later dates. The first edition of the processing bulletin was published in January, 1930, and this is the eighth edition. The processes given in the present bulletin are based upon technological data relating to the heat resistance of spoilage bacteria in canned foods and upon data pertaining to heat penetration in canned foods.

In some instances process suggestions are based upon analogy with similar products for which heat resistance and heat penetration data are available, and also on the general experience of the canning industry.

It should be understood that when further data and information are available the bulletin will be revised, and previous editions should be discarded.

Prefacing the list of processes are recommendations with respect to proper retort equipment and its operation for best results. A thorough understanding of these recommendations is necessary for the best use of the bulletin and is essential for the correct interpretation and proper use of the processes.

Following the list of processes is an appendix which gives information regarding sources of spoilage contamination and its control; the significance of sugar and starch contamination; and Federal minimum drained weights for spinach and mushrooms for which maximum drained weights are specified in conjunction with process recommendations.

While the procedures recommended in this bulletin are based on sound theory and wide practical experience, references to methods or types of equipment are not to be construed as a guarantee of their sufficiency. The recommendations contained herein are not to be considered as creating any assurance or warranty with respect to production or cost or any responsibility for damage, spoilage, loss, accident or injury resulting from the use of this information by anyone.

IMPORTANCE OF PROPER EQUIPMENT AND PROCEDURE

Close supervision of the cook room and careful attention to details are essential to ensure successful processing; otherwise, irregularities may occur due to poor organization of the cook room, to carelessness, or to ignorance of safe practices.

In order to be certain that all cans secure the amount of heat treatment required to prevent spoilage, careful control and recording of temperatures and adequate venting of air from all parts of the retort are essential, because processes for canned foods are determined by tests made with the cans in "pure" steam (free of air) at a definitely controlled and specified temperature, and when these processes are applied in commercial practice identical conditions must be met. The suggestions under "Equipment" and "Procedure" are based on the results of careful studies to determine what type of equipment and procedure may be relied upon to give the required heat treatment under commercial conditions.

EQUIPMENT

Type of Retort

The processes contained in this bulletin are for discontinuous, non-agitating (still) retorts. For other types of retorts, processes should be obtained from a laboratory connected with the canning industry. For retorts to be used in processing metal or glass containers under water with superimposed air pressure, see NCA Bulletin 30-L.

Retort Equipment

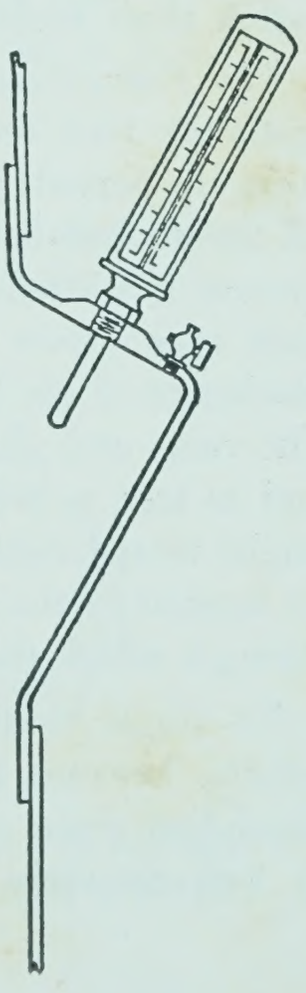
Control and indicating equipment such as thermometers and pressure gauges should be so placed with respect to light and position that they are easily readable.

For proper operation each retort should have the items of equipment named below:

(1) *Controller.* An automatic controller to maintain accurately the temperature at the specified point.

(2) *Indicating Mercury-in-Glass Thermometer.* This thermometer should have a temperature range of not more than 100°F., for example, 170°F. to 270°F., and the scale divisions should be of either one degree or two degrees each—never greater than two degrees. The temperature scale of the indicating thermometer should be at least 7 inches in length, and the thermometer should have a pressure scale corresponding to the temperature scale at the altitude above sea level at which the retort is located. The relation between the temperature and pressure scales at various altitudes is given in the table on page 20. The pressure scales of all thermometers should be adjusted in correspondence with these data.

Bulbs of indicating thermometers may be installed within the retort shell or in external wells attached to the retort. External wells should communicate with the principal chamber of the retort through openings having an area not less than that of a circle of ¾-inch diameter. All external wells or pipes must be equipped with at least 1/16-inch bleeders so located as to provide a full flow of steam past the entire length of the thermometer bulb. The bleeder should emit steam continuously and freely during the processing period. A suitable thermometer well is shown in the sketch. If containers are processed under water, the hemispherical well shown in Bulletin 30-L should be used.



(3) *Recording Thermometer.* The chart should be easily readable to 1°F. and should be graduated in not to exceed 2°F. divisions within the range of plus or minus 10°F. of the process holding temperature used. All charts should have a working scale of not less than 3 inches. The bulb may be installed within the retort shell or in a thermometer well attached to the shell. This well should be capable of accommodating both the recorder bulb and a mercury-in-glass thermometer.

(4) *Pressure Gauge.* The pressure gauge should be graduated in 1-pound divisions, and have a range to 30 pounds. The minimum diameter of the dial should be 4½ inches and the gauge should preferably be of a type in which the operating mechanism is independent of the case. Compound type gauges, having both vacuum and pressure scales, are advantageous. The gauge should be connected to the retort by means of a gauge siphon or goose neck.

(5) *Stacking Equipment.* Baskets, trays, gondolas, etc., for holding stacked cans should preferably be of strap iron. Solid or insufficiently perforated metal trays, dividers, crates, or gondolas should not be used, for such equipment can lead to the formation of low temperature regions. When perforated metal baskets are used the perforations in the bottoms should be at least 1 inch holes on 1¾ inch centers, or their equivalent (½ inch on 1 inch centers, ¾ inch on 1½ inch centers, 1½ inch on 2½ inch centers, or 1¾ inch on 3 inch centers).

(6) *Stacking of Cans.* Cans should be so stacked as to permit the free circulation of steam throughout the retort load. If it is necessary to separate two lots in one crate or tray, fish net or onion sacks of ½ inch, or larger, mesh should be used rather than burlap or other tightly woven material.

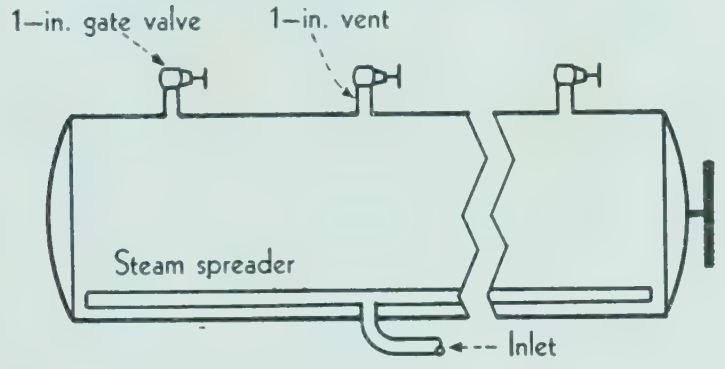
(7) *Valve-Controlled Vents.* Vents are *large* valve-controlled openings into retorts used for elimination of air during the come-up period. They should be installed in such a way that all the air can be removed from the retort before timing of the process is started. Vents should be controlled by gate, or plug-cock type valves which should be fully open to permit rapid discharge of air from the retort during the coming-up period. The vents and all external lines, manifolds, etc. should be short and as free as possible from bends and other conditions which might retard rapid discharge of air. The outlet pipes should be located in the extreme opposite wall of the retort from that through which the steam is admitted.

No single venting specification is entirely applicable to all retorts, because the choice of a satisfactory specification is dependent upon size, shape, and present equipment of retorts, as well as upon quantity and pressure of steam available,

method of stacking cans in the retort, length of coming-up time desired, resistance to outward flow of air from the retort, etc.

Six suggested installations and operating procedures are given in the following diagrams. *Increased venting may be necessary when systems employing divider plates between each layer of cans are used. Where such systems are used, consult a laboratory connected with the canning industry.*

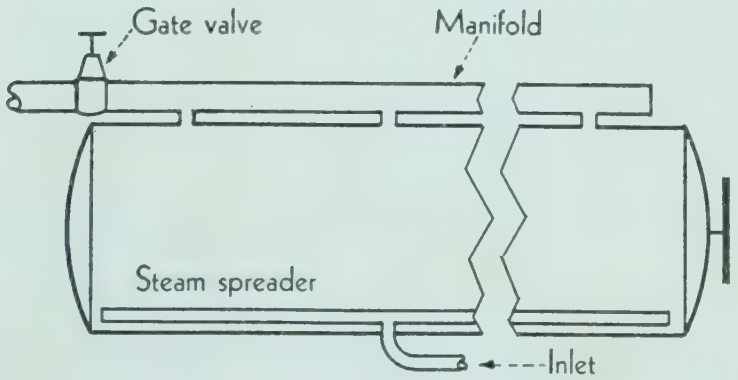
A—Venting through multiple 1-in. vents discharging directly to atmosphere



Specifications: One 1-in. vent for every 5 ft. of retort length, equipped with a gate valve and discharging to atmosphere; end vents not more than 2½ ft. from ends of retort.

Venting method: Valve should be wide open for at least 5 minutes to at least 225°F., or for at least 7 minutes to at least 220°F.

B—Venting through multiple 1-in. vents discharging through a manifold to atmosphere

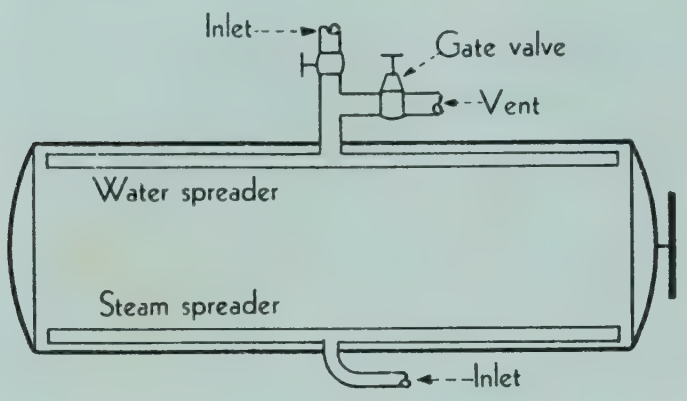


Specifications: One 1-in. vent for every 5 ft. of retort length; end vents not over 2½ ft. from ends of retort;

size of manifold—for retorts less than 15 ft. in length, 2½-in.; for retorts over 15 ft. in length, 3-in.

Venting method: Manifold vent valve should be wide open for at least 6 minutes to at least 225°F., or for at least 8 minutes to at least 220°F.

C—Venting through water spreaders



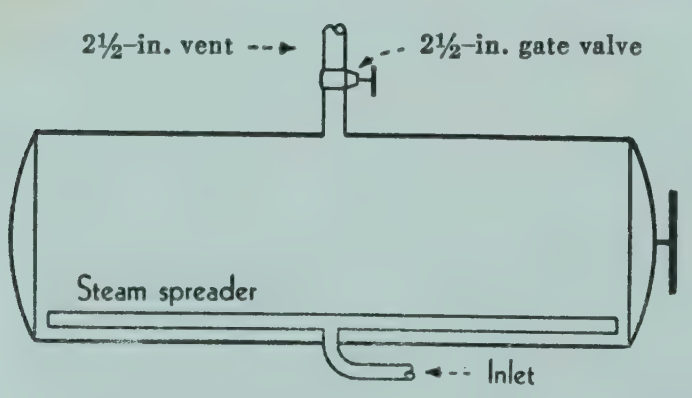
Size of water inlet, vent pipe, and vent valve: For retorts less than 15 ft. in length, 2-in.; for retorts over 15 ft. in length, 2½-in.

Size of water spreader: For retorts less than 15 ft. in length, 1½-in.; for retorts over 15 ft. in length, 2-in.

Number of holes in water spreader: This is an important consideration, and may be governed by local regulations; if not, a laboratory connected with the canning industry should be consulted.

Venting method: Water spreader vent valve should be wide open for at least 5 minutes to at least 225°F., or for at least 7 minutes to at least 220°F.

D—Venting through a single 2½-in. top vent (for retorts not exceeding 15 ft. in length)

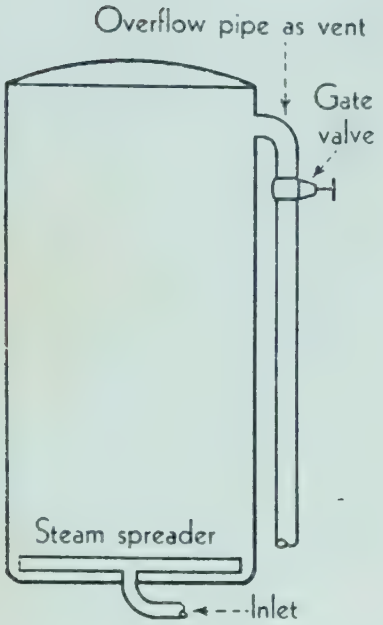


Specifications: A 2½-in. vent equipped with a 2½-

in. gate valve and within 2 ft. of the center of the retort.

Venting method: Valve should be wide open for at least 4 minutes to at least 220°F.

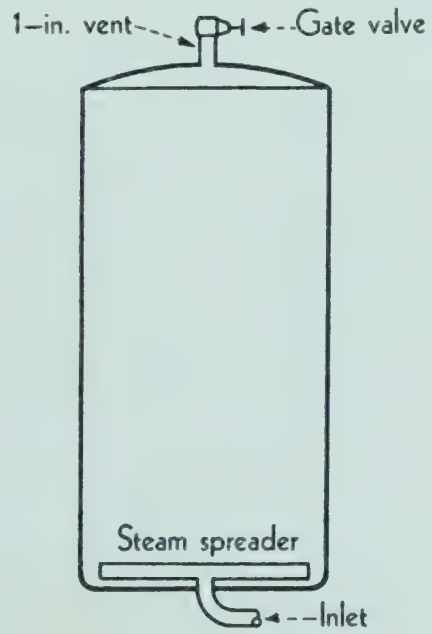
E—Venting through a 1½-in. overflow



Specifications: A 1½-in. overflow pipe equipped with a 1½-in. gate valve and with not more than 6 ft. of 1½-in. pipe beyond the valve.

Venting method: Valve should be wide open for at least 4 minutes to at least 218°F., or for at least 5 minutes to at least 215°F.

F—Venting through a single 1-in. top vent



Specifications: A 1-in. vent in lid, equipped with a 1-in. gate valve and discharging directly into the atmosphere.

Venting method: Valve should be wide open for at least 5 minutes to at least 230°F., or for at least 7 minutes to at least 220°F.

(6) *Bleeders.* Besides the thermometer bleeders, additional bleeders are necessary, located in the extreme opposite wall of the retort from that at which steam is admitted. These bleeders should be of ⅛-inch size. A horizontal retort should have one

bleeder within 12 inches of each end and additional bleeders not more than 8 feet apart. A vertical retort should have one bleeder at the end opposite to that at which steam is admitted. Bleeders should be open and emit steam continuously and freely during the entire process, including the coming-up time. All bleeders should be arranged in such a way that the operator can observe that steam is escaping during the process.

(7) *Drain Valve.* There should be a drain valve of adequate size to permit the rapid removal of water after cooling. Under some operating conditions the drain valve may be used as a vent.

(8) *Steam Line.* The steam line should lead to a perforated pipe within the retort. The pipe should be so perforated as to ensure proper distribution of steam during the processing period. With horizontal retorts the perforated pipe should extend along the bottom for the entire length of the retort and the perforations should be along the top of this pipe. In vertical retorts the perforated pipe is usually in the form of a cross with the perforations along the top or sides of the pipe.

(9) *By-Pass.* A steam by-pass for the control valve is desirable to make possible hand operation of the retort in the event of a breakdown of the control valve, and also to admit steam rapidly during the coming-up period when steam is usually demanded in larger quantities than the control valve is capable of handling. This steam by-pass should be at least equal in diameter to the pipe bringing the steam to the retort.

(10) *Safety Valve.* Safety valves of adequate capacity are necessary to prevent excess pressure in retorts. These should comply with local safety codes or the A.S.M.E. code for unfired pressure vessels. For details regarding the A.S.M.E. code, see "Accident Prevention Manual for Industrial Operations", Section 4 Pressure Vessels, published by the National Safety Council Inc., 425 North Michigan Avenue, Chicago 11, Illinois. Section 4 may be obtained as a separate reprint.

Pressure Cooling Equipment

If the cans are to be cooled under pressure, equipment in addition to that described above will be necessary. For information in regard to such equipment or in regard to the oper-

ation of retorts, a laboratory connected with the canning industry should be consulted.

Maintenance of Equipment

Processing equipment should be maintained in a satisfactory operating condition. Safety valves should be tested frequently. Instruments (gauges, thermometers, recorders) should be checked for accuracy at least once a year. Water valves and compressed air valves, especially the latter, should be checked frequently for leaks.

Before each operating season and after any considerable idle period, the entire retort hook-up should be examined carefully, and each retort should be brought to processing temperature (without a load) to test the steam line for leaks, to check the vents, and to test the instruments and control equipment for proper operation and accurate recording. Never introduce water into an empty retort after testing until the pressure has been released.

PROCEDURE

All cans should be so closed and processed that the ends will remain concave under all commercial storage conditions regardless of temperature and altitude. To satisfy such conditions, commercial experience has indicated that with products packed in brine without steam flow or mechanical vacuum closure, the average temperature (temperature of the contents of the can after thorough mixing) of the contents of each can at the time of closure should be at least 130°F. Cans of large diameter may require a much higher closing temperature to prevent distortion of the ends during processing. For many products a higher vacuum than that obtained from having an average closing temperature of 130°F. will be necessary in order to maintain the canned product in good condition.

Acidification

Unless some acidification procedure is followed, sterilization of certain low-acid foods by heat produces unmerchantable

products. Notable examples are Globe artichokes, onions and green peppers. A health hazard is involved in the case of insufficient acidification. Under proper control such products may be acidified to the point where they are no longer low-acid and then be processed in boiling water. However, this procedure should not be followed without consulting a laboratory connected with the canning industry. Experience has shown that careful supervision of all details, particularly the blanch, fill and brine, is essential when acidification is included in the processing procedure.

Coding

All containers should be coded by marks to identify the time of packing. The time period during which each code lot is packed should be as short as practicable—in no case longer than one day. Strict adherence to this rule has proved to be good economy.

Process

The term "process" as used in this bulletin designates the heat treatment expressed in terms of temperature and time given the product after the container is permanently sealed. The basic, or minimum, requirement for the process for any product is that it be sufficient to destroy the organism of greatest known resistance to heat which, by reason of its survival, may be detrimental to health.

The efficiency of any process is dependent on the heat resistance and the number of bacteria in the product. In general, the processes presented in this bulletin are regarded as adequate when something greater than a minimum number of spoilage organisms is present. In some cases contamination with spoilage bacteria may be so high and the bacteria of such great resistance to heat that the suggested process may be inadequate to prevent spoilage, and it is therefore essential that such contamination be kept as low as possible. (See Appendix for information regarding precautions which should be taken to keep the number of spoilage organisms at a minimum.)

Operation of Cook Room

In order to minimize the possibility of mistakes and reduce

the danger of unprocessed or underprocessed cans reaching the warehouse, it is recommended that:

(1) Processes for all products being packed be posted in a conspicuous place near the retorts.

(2) All baskets, trucks, cars or crates containing unretorted material be plainly and conspicuously marked. If several products are being packed at the same time, each product should also be plainly indicated.

(3) A distinctive marker be hung from the retort opening when the retort holds unprocessed cans. It should be so placed that the door or lid cannot be closed before the marker is removed.

(4) A retort not be closed until the operator indicates that he is ready to start the process.

(5) Cans of unknown status with regard to process and found on the cook room floor be picked up periodically, punctured and thrown out.

(6) Adequate precautions be taken to clear exhaust boxes and precookers of all cans at the end of each day's operations.

Rapid Handling and Prompt Retorting of Filled Cans

A long holding period between filling and closing or between closing and retorting cans may result in souring, off-flavor, and loss of vacuum. Depending upon the nature of the product, processing should follow within one-half to one hour after closure. If longer times are required to obtain enough cans to fill a retort, processing of partial retort loads should be practiced.

Position of Cans in Retort

Heat penetration in canned foods containing freely flowing liquid is mainly by convection currents. The general trend of these currents is in a vertical direction, consequently in the product being heated they seek channels which permit such motion. Where their progress is impeded or baffled by solid material, the currents flow around the obstruction to the nearest point at which they can pass. For this reason the alignment of certain foods in the can is of the greatest importance as regards heat penetration.

Where the packing or filling of any product in the can results in stratification, the cans should be processed in such position that the plane of stratification is vertical. In the case of asparagus, for example, the spears are generally parallel and tightly packed in the cans in a vertical position, so that the channels containing liquid are parallel to the spears. As a result, the speed of heat penetration is greater when the cans are placed upright in the retort.

Another example is spinach. In No. 10 cans especially, the spinach is placed in more or less horizontal layers. Convection currents, therefore, travel to the center of the cans faster when the cans are processed on their sides than when in a vertical position.

Products such as peas and cut green beans consist of small solid bodies, fairly uniform in size and evenly distributed throughout a liquid medium; consequently the rate of heat penetration is little influenced by the position of the cans in the retort.

Initial Temperature

The term "initial temperature" as used herein designates the average temperature of the can contents at the time steam is turned on for the process. Just prior to the start of the process, the contents of the container used for checking the initial temperature should be shaken or stirred and the temperature determined. This container should be respresentative of the coldest cans in the retort load and should have an initial temperature equal to or greater than the initial temperature specified in this bulletin. The specified initial temperature is to be regarded as a prerequisite minimum of the process suggested. If a can is closed at a temperature higher than that of the canning room atmosphere and is then held for some time in the room before it is processed, the contents will cool but the temperature at the center of the can may not be appreciably less than the closing temperature. It is for this reason that, from the standpoint of sterilization, the contents of the container should be stirred or shaken and the initial average temperature determined just prior to the start of the process.

"Initial temperature" should not be confused with "closing temperature". Except when vacuum packing or steam flow closure is practiced, the closing temperature is the major factor influencing the final vacuum obtained in the cans and is an important consideration in preventing undue can strain or damage during processing and cooling and in avoiding development of flippers. The closing temperature must be sufficiently high to satisfy these needs, and this will, in many instances, result in initial temperatures considerably above the minimum specified as a prerequisite to the processes listed.

Starting a Process—Venting—Coming-up Time

At the time the steam is turned on, all bleeders and all valve-controlled vents should be wide open. All bleeders should be left open during the processing period.

Venting. The valve-controlled vents should be left open for a sufficient time after steam is turned on to ensure that all air is swept out of the retort, so that no "pockets" of air remain among the cans. There is a tendency for steam to by-pass the load of cans and to escape through the vents before all air has been driven from the stacks of cans. On page 8 are the venting specifications designed to provide for satisfactory operations.

An air-steam mixture in the retort will cause a non-uniform heat distribution, resulting in a lowering of the rate of heat transfer to the containers. The timing of the process should not begin, even though the proper temperature is indicated, until temperature and pressure instruments on the retort give corresponding readings (see table on page 20).

Lack of agreement between temperature and pressure instruments is an indication of the presence of air in the retort. However, if proper venting procedure is not followed, there can be a "pocket" containing air in a region of the retort that is remote from the thermometer, and the presence of this "air pocket" may not be indicated by a detectable disagreement between the temperature and pressure indicators.

Coming-up Time. There is a minimum limit for the coming-up time because of the necessity for removing the air from the retort by venting during this period. When venting is inadequate for rapid removal of the air, the use of a very short

coming-up time is likely to result in an unsterilized product. A coming-up time shorter than the minimum for which the retort has been demonstrated to give satisfactory results with its existing hook-up and specified operating technique should not be used.

With some vacuum-packed products, it is advisable to heat the cans sufficiently to dissipate the internal vacuum before the pressure in the retort is permitted to become greater than two pounds, otherwise the cans may panel or even collapse.

Process Temperatures

The quality of most products will be least affected by the process if the retorts are brought to processing temperature quickly and the process is followed by prompt and rapid cooling. (Some vacuum-packed products are an exception, for the reason given above.) This procedure not only protects the quality of the product but also shortens the total time required for each processing cycle and so effects time economy in the use of the retorts. It applies to all processing temperatures and is especially important when the temperature is above 240°F.

If any deviation from the processes given in this bulletin is desired, a laboratory connected with the canning industry should be consulted.

Short High Temperature Processes. For a product having rapid heat penetration, very short processes at comparatively high temperatures are sometimes used. It is especially important that such processes have the most careful control. An error in either time or temperature in a short high temperature process will have a much greater effect upon the total sterilizing value of the process than a like error will have in a longer process at a lower temperature.

Boiling Water Processes. The sterilizing of low-acid products in boiling water is impracticable without controlled acidification procedures. Without acidification continuous boiling for over ten hours is necessary to secure a sterilizing efficiency equivalent to that of the processes listed in this bulletin.

Cooling and Storage

The duration of the water-cooling period should be sufficient to bring the average temperature of the contents to 100°F., but

water cooling should not be continued to the point where external rusting of the container may occur. In humid locations water cooling to a temperature of 100°F. may lead to external rusting. In that case, water cooling should be carried to approximately 120°F. and the cans subsequently air cooled before they are put into storage. When cans whose contents are at temperatures substantially above 100°F. are stacked closely together, and especially if they are sealed in fiber cases, they cool so slowly that spoilage by thermophilic bacteria and injury by heat to the quality of the product (stack-burn) may occur.

Air Cooling

If the capacity of the water-cooling equipment is inadequate, or if a shortage of water is experienced, the cans should be so stacked that they will air cool rapidly. Air cooling is sometimes used for products such as hominy in order to effect a proper swelling of the product. It is suggested that the cans be stacked on their sides in single rows, allowing space for air circulation between the rows. The stacks should be arranged parallel to the cross ventilation of the warehouse. Careful attention to the factors affecting air circulation may serve to prevent retarded cooling and to safeguard against spoilage by thermophilic bacteria.

Corresponding Gauge Pressures and Process Temperatures

The following table shows the gauge pressure corresponding to specified process temperatures at various altitudes:

GAUGE PRESSURE CORRESPONDING TO SPECIFIED PROCESS TEMPERATURES AT VARIOUS ALTITUDES

Temp.	Sea	Feet above sea level							Temp.
Deg. F.	Level	500	1000	2000	3000	4000	5000	6000	*Deg. C*
200	....	....	....	....	....	....	....	....	93.3
205	....	....	....	....	....	....	0.5	0.9	96.1
210	....	....	....	0.4	0.9	1.4	1.8	2.3	98.9
212	0.0	0.2	0.5	1.0	1.5	2.0	2.4	2.9	100.0
215	0.9	1.1	1.4	1.9	2.4	2.9	3.3	3.8	101.7
220	2.5	2.7	3.0	3.4	3.9	4.4	4.9	5.3	104.4
225	4.2	4.5	4.7	5.2	5.7	6.2	6.6	7.1	107.2
230	6.1	6.3	6.6	7.1	7.6	8.0	8.5	9.0	110.0
235	8.1	8.3	8.6	9.1	9.6	10.0	10.5	11.0	112.8
240	10.3	10.5	10.8	11.3	11.7	12.2	12.7	13.1	115.6
242	11.2	11.4	11.7	12.2	12.7	13.1	13.6	14.1	116.7
245	12.6	12.9	13.1	13.6	14.1	14.6	15.0	15.5	118.3
248	14.1	14.3	14.6	15.1	15.6	16.0	16.5	17.0	120.0
250	15.1	15.4	15.6	16.1	16.6	17.1	17.5	18.0	121.1
252	16.2	16.4	16.7	17.2	17.7	18.1	18.6	19.1	122.2
255	17.8	18.1	18.3	18.8	19.3	19.8	20.2	20.7	123.9
260	20.7	21.0	21.2	21.7	22.2	22.7	23.1	23.6	126.7

CAUTION

To facilitate the presentation of the process times and temperatures in tabular form, it has been necessary to use a number of footnotes. Those who use the bulletin are cautioned to read the footnotes in connection with the tables to which they refer.

CAN DIMENSIONS

The can sizes are given in the nomenclature usually employed in the industry, which avoids the confusion incident to conflicting local names of cans.

In this system the cans are identified by a statement of their dimensions (over-all diameter and over-all height). Each dimension is expressed as a number of three digits. The left-hand digit gives the number of whole inches, while the two right-hand digits give the additional fraction of the dimension expressed as sixteenths of an inch.

The first number given in the size of each can is the diameter, and the second number is the height. For example, a No. 2 can, designated as 307x409, is $3\frac{7}{16}$ inches in diameter and $4\frac{9}{16}$ inches high, that is, within manufacturing tolerances.

The dimensions are "over-all," the diameter being measured to the outside of the double seam, and the length including the entire seam at each end of the can.

PROCESS TABLES

I.—VEGETABLES AND VEGETABLE PRODUCTS

Artichokes, Globe

Pressure cooks adequate for sterilization render artichokes and artichoke hearts unmerchantable. The Standard of Identity promulgated under the Food, Drug and Cosmetic Act recognizes the necessity of acidifying artichokes. Such acidification permits safe processing in boiling water and thereby ensures preservation without loss of merchantability. Careful supervision of all details, particularly blanch, fill, and brine, is essential when acidification is included in the processing procedure. These products should not be packed without consulting a laboratory connected with the canning industry.

Asparagus spears, white and white-green

Can Name	Dimensions	Initial temperature	Time at (*a*) 240° F.	Time at (*a*) 248° F.
		Deg. F.	*Min.*	*Min.*
			Tips Down	
No. 2½ & smaller	401x411	70	25	16
	& smaller	120	23	14
			Tips Up	
No. 2½ & smaller	401x411	70	27	19
	& smaller	120	26	18

(*a*) Two series of processing times are shown in the last two columns headed tips down and tips up. These headings refer to the position of the spears in the retort during processing. Processing the cans in a vertical position is very important.

Asparagus spears, all green

Can Name	Dimensions	Initial temperature	Time at (a) 240° F.	Time at (a) 248° F.
		Deg. F.	*Min.*	*Min.*
			Tips Down	
No. 2½ & smaller	401x411 & smaller	70	27	17
		120	25	15
			Tips Up	
No. 2½ & smaller	401x411 & smaller	70	27	19
		120	26	18

Asparagus cuts, white or green, including soup cuts

Can Name	Dimensions	Initial temperature	Time at 240° F.	Time at 248° F.
		Deg. F.	*Min.*	*Min.*
No. 2½ & smaller	401x411 & smaller	70	26	16
		120	25	15
No. 10	603x700	70	32	20
		120	30	18

(*a*) Two series of processing times are shown in the last two columns headed tips down and tips up. These headings refer to the position of the spears in the retort during processing. Processing the cans in a vertical position is very important.

Baby food, chopped: *See* Vegetables, chopped

Baby food, strained: *See* Vegetables, strained

Beans, green or wax, whole or cut (*a*)

Can Name	Dimensions	Initial temperature	240° F.	Time at 245° F.	250° F.
		Deg F.	*Min.*	*Min.*	*Min.*
No. 2 & smaller	307x409 & smaller	70	21	16	12
		120	20	15	11
No. 2½	401x411	70	26	19	15
		120	25	18	14
No. 3 Cylinder	404x700	70	32	22	18
		120	30	20	16
No. 10	603x700	70	37	27	22
		120	35	25	20

Beans, green or wax, asparagus style (*a*) (*b*)

Can Name	Dimensions	Initial temperature	Time at 240° F.
		Deg. F.	*Min.*
No. 2 & smaller	307x409 & smaller	70	26
		120	25
No. 10	603x700	70	50
		120	45

Beans, green or wax, Sliced Lengthwise or French style (*a*)

Can Name	Dimensions	Initial temperature	Time at 240° F.	Maximum drained weight
		Deg. F.	*Min.*	*Oz.*
No. 2	307x409	70	26	14
		120	25	
No. 10	603x700	70	50	70
		120	45	

Beans, Kidney: *See* Beans, mature, etc.

(*a*) These processes apply only to beans that are properly blanched.

(*b*) All cans of asparagus style beans should be processed in a position such that the beans are upright in the retort.

Beans, Lima, succulent (*a*)

Can Name	Dimensions	Initial temperature	240° F.	Time at 245° F.	250° F.
		Deg. F.	*Min.*	*Min.*	*Min.*
No. 2 & smaller	307x409 & smaller	70	40	27	20
		140	35	25	18
No. 3 Cylinder	404x700	70	55	38	28
		140	50	35	25
No. 10	603x700	70	60	45	35
		140	55	40	30

Beans, mature, and soaked dried legumes, shelled types, in brine

Can Name	Dimensions	Initial temperature	240° F.	Time at 245° F.	250° F.
		Deg. F.	*Min.*	*Min.*	*Min.*
No. 2½ & smaller	401x411 & smaller	100–140	45	30	20
No. 10	603x700	100–140	70	55	40

Beans, Soy

Can Name	Dimensions	Initial temperature	240° F.	Time at 245° F.	250° F.
		Deg. F.	*Min.*	*Min.*	*Min.*
No. 2 & smaller	307.409 & smaller	70	45	27	20
		140	40	25	18
No. 10	603x700	70	70	55	40
		140	65	50	35

(*a*) For "lima beans, dry soaked" the processes given under "Beans, mature, etc." should be used.

Beans in Sauce

The process necessary for the sterilization of beans in sauce depends to a considerable extent upon the sauce formulation with respect to tomato pulp and starch content. The processes in the three tables which follow are designed to fit three ranges of sauce formulation. If the formulation used does not fall within the specified limits of ingredients, the proper process should be obtained from a laboratory connected with the canning industry.

Beans in Heavy Sauce, with or without pork, or baked beans

Can Name	Dimensions	Initial temperature	Time at 240° F.	Time at 245° F.	Time at 250° F.
		Deg. F.	*Min.*	*Min.*	*Min.*
No. 1 (Picnic)	211x400	100	75	65	55
		140	70	60	50
		180	60	50	45
Kitchenette	307x214	100	80	70	65
		140	75	65	60
		180	65	55	50
No. 300	300x407	100	90	80	70
		140	80	70	60
		180	70	60	50
No. 303	303x406	100	95	85	75
		140	85	75	65
		180	75	65	55
No. 303 Cylinder, No. 95	303x509, 307x400	100	100	90	80
		140	90	80	70
		180	75	70	60
No. 2	307x409	100	105	95	85
		140	95	85	75
		180	80	70	65
Jumbo, No. 2 Cylinder	307x510, 307x512	100	105	100	90
		140	95	90	80
		180	80	75	65
No. 2½	401x411	100	130	115	110
		140	115	100	95
		180	95	85	80
No. 10	603x700	100	235	215	200
		160	210	190	175

Beans, with or without pork, in tomato sauce containing no added starch and 10 to 20 gallons of tomato pulp (1.045 sp. gr.) per 100 gallons sauce

Can Name	Dimensions	Initial temperature	Time at 240° F.	Time at 245° F.	Time at 250° F.
		Deg. F.	*Min.*	*Min.*	*Min.*
No. 2½ & smaller	401x411 & smaller	100–140	65	45	35
No. 10	603x700	100–140	100	75	55

Beans, with or without pork, in tomato sauce containing no added starch and 10 gallons or less of tomato pulp (1.045 sp. gr.) per 100 gallons sauce

Can Name	Dimensions	Initial temperature	Time at 240° F.	Time at 245° F.	Time at 250° F.
		Deg. F.	*Min.*	*Min.*	*Min.*
No. 2½ & smaller	401x411 & smaller	100–140	45	30	20
No. 10	603x700	100–140	70	55	40

Bean sprouts

Can Name	Dimensions	Initial temperature	Time at 240° F.	Time at 250° F.
		Deg. F.	*Min.*	*Min.*
No. 2½ & smaller	401x411 & smaller	70	21	12
		140	20	11

Beets, whole, cut, quartered, diced, sliced, or shoestring, in brine (*a*)

Can Name	Dimensions	Initial temperature	Time at 240° F.	Time at 250° F.
		Deg. F.	*Min.*	*Min.*
No. 2½ & smaller	401x411 & smaller	70	35	23
		140	30	20
No. 10 (except sliced)	603x700	70	45	30
		140	40	25
No. 10 (sliced)	603x700	70	50	35
		140	45	30

(*a*) If beets are lye-peeled, the cooks apply only provided the lye has been completely removed by washing.

Beet tops: *See* Spinach

Broccoli, green sprouting (*a*)

Can Name	Dimensions	Initial temperature	Time at 240° F.
		Deg. F.	*Min.*
Jumbo	307x510	70	35
No. 2 Cylinder	307x512	140	30

Cabbage, in sections (*b*)

Can Name	Dimensions	Initial temperature	Time at 240° F.	Time at 250° F.
		Deg. F.	*Min.*	*Min.*
No. 2½	401x411	70	45	30
		140	40	25

Carrots, whole, cut, quartered, sliced, diced or shoestring, in brine (*c*)

Can Name	Dimensions	Initial temperature	Time at 240° F.	Time at 250° F.
		Deg. F.	*Min.*	*Min.*
No. 2½ & smaller	401x411 & smaller	70	35	23
		140	30	20
No. 10 (except sliced)	603x700	70	45	30
		140	40	25
No. 10 (sliced)	603x700	70	50	35
		140	45	30

Carrots and Peas: *See* Peas and Carrots

Carrot Juice: *See* Specialties

Cauliflower

Can Name	Dimensions	Initial temperature	Time at 240° F.
		Deg. F.	*Min.*
No. 2½ & smaller	401x411 & smaller	70	21
		140	20

(*a*) All cans of broccoli should be processed in a position such that the sprouts are upright in the retort.

(*b*) The weight of cabbage filled into No. 2½ cans should not exceed 17 ounces. These processes should not be applied to other styles of pack because variation in canning procedure may vary the heat penetration. Where it is desired to can cabbage in other styles, a laboratory connected with the canning industry should be consulted.

(*c*) Other styles of carrots, including carrot chips, should not be packed without directions from a laboratory connected with the canning industry. If carrots are lye-peeled, the cooks apply only provided the lye has been completely removed by washing. If carrots are packed "asparagus style," the cans should be processed on end.

Celery Cuts

Can Name	Dimensions	Initial temperature	Time at 240° F.
		Deg. F.	*Min.*
No. 2 & smaller	307x409 & smaller	70	28
		140	25
No. 2½	401x411	70	33
		140	30
No. 10	603x700	70	45
		140	40

Celery hearts (*a*)

Can Name	Dimensions	Initial temperature	Time at 240° F.
		Deg. F.	*Min.*
Quart Olive & smaller	307x704 & smaller	70	28
		140	25
No. 2½	401x411	70	33
		140	30

Corn, cream style, or Succotash (*b*)

Can Name	Dimensions	Initial temperature	240° F.	Time at 245° F.	250° F.
		Deg. F.	*Min.*	*Min.*	*Min.*
8Z Tall	211x304	140	75	65	55
		160	70	60	50
		180	65	55	45
No. 1 (Picnic)	211x400	140	80	70	60
		160	75	65	55
		180	70	60	50
No. 303	303x406	140	95	85	75
		160	90	80	70
		180	85	75	65
No. 2	307x409	140	105	95	85
		160	100	90	80
		180	90	80	70
No. 3 Cylinder	404x700	140	160	145	130
		160	150	135	120
		180	135	120	105
No. 10	603x700	140	220	205	195
		160	205	190	180
		180	180	165	155

(*a*) Cans of celery packed "asparagus style" should be processed in a position such that the celery is upright in the retort.

(*b*) These processes apply to succotash prepared from cream style corn and beans. For succotash prepared from whole kernel corn and beans use the processes suggested for whole kernel corn in brine.

Corn, whole kernel in brine (*a*)

Can Name	Dimensions	Initial temperature	Time at 240° F.	Time at 245° F.	Time at 250° F.
		Deg. F.	*Min.*	*Min.*	*Min.*
No. 2 & smaller	307x409 & smaller	100	55	40	30
		140	50	35	25
No. 3 cylinder	404x700	140	65	45	35
No. 10	603x700	140	85	60	45
		160	80	55	40

Corn, whole kernel, vacuum pack (*b*)

Can Name	Dimensions	Initial temperature	Time at 240° F.	Time at 245° F.	Time at 250° F.
		Deg. F.	*Min.*	*Min.*	*Min.*
No. 2 Vacuum	307x306	70–160	55	45	35

Corn on the cob

Processes necessary for vacuum packed corn on the cob are dependent to a marked degree upon the factors of maturity, variety, fill, amount of water added, and conditions tending to reduce the vacuum. It should not be packed without directions from a laboratory connected with the canning industry.

Dandelion greens: *See* Spinach

Hominy, lye or pearl

Can Name	Dimensions	Initial temperature	Time at 240° F.
		Deg. F.	*Min.*
No. 2	307x409	70–160	75
No. 2½	401x411	70–160	90
No. 10	603x700	70–160	120

(*a*) These processes apply only if the corn is well cleaned.

(*b*) The processes given above are dependent on the following factors for maintenance of their intended sterilizing value: (1) The maintenance of 23 inches of can vacuum immediately before processing; (2) the presence of at least one ounce of free liquid; (3) the control of fill-in weight not to exceed 11¼ ounces of washed corn.

Kale: *See* Spinach

Mushrooms, buttons, whole, sliced or pieces and stems, in brine (*a*)

Can Name	Dimensions	Initial temperature	Time at 250° F.	Maximum drained weight (*b*)
		Deg. F.	*Min.*	*Oz.*
2Z Mushroom	202x204	70–140	18	2.3
4Z Mushroom	211x212			4.5
8Z Mushroom	300x400			8.5
Jumbo	307x510	70–140	25	16.5
No. 10	603x700	70–140	30	70

Mustard greens: *See* Spinach

Okra, Northern style (fermented)

Can Name	Dimensions	Initial temperature	Time at 240° F.
		Deg. F.	*Min.*
No. 2 & smaller	307x409 & smaller	70	20
		140	17
No. 2½	401x411	70	23
		140	20
No. 10	603x700	70	40
		140	35

Okra, Southern style (unfermented)

Can Name	Dimensions	Initial temperature	Time at 240° F.	Time at 250° F.	Maximum fill-in weight
		Deg. F.	*Min.*	*Min.*	*Oz.*
No. 1 (Picnic)	211x400	70	35	25	6.6
		140	30	20	
No. 2	307x409	70	35	25	12.3
		140	30	20	
No. 2½	401x411	70	40	30	18
		140	35	25	
No. 10	603x700	70	55	45	66
		140	45	35	

(*a*) These processes do not apply to mushroom "chips." For styles of pack other than those listed, consult a laboratory connected with the canning industry.

(*b*) For the minimum drained weights contained in the Standard for Fill of Container promulgated under the Federal Food, Drug and Cosmetic Act, see page 55.

Onions

Pressure cooks adequate for sterilization render onions unmerchantable. It has been found necessary, therefore, to acidify this product to permit safe processing in boiling water and thereby ensure preservation without loss of merchantability. Careful supervision of all details, particularly blanch, fill and brine is essential when acidification is included in the processing procedure. This product should not be packed without consulting a laboratory connected with the canning industry.

Parsnips (*a*)

Can Name	Dimensions	Initial temperature	Time at 240° F.
		Deg. F.	*Min.*
No. 2½ & smaller	401x411 & smaller	70	33
		140	30
No. 10	603x700	70	45
		140	40

Peas, in brine (*b*)

Can Name	Dimensions	Initial temperature	240° F.	Time at 245° F.	250° F.
		Deg. F.	*Min.*	*Min.*	*Min.*
No. 2 & smaller	307x409 & smaller	70	36	26	16
		140	35	25	15
No. 3 Cylinder	404x700	70	50	32	22
		140	45	30	20
No. 10	603x700	70	55	37	25
		140	50	35	23

Peas, dry soaked: *See* Beans, mature, etc.

Peas, Black-eye: *See* Beans, mature, etc.

Peas, Crowder: *See* Beans, mature, etc.

(*a*) These cooks apply only to a brine pack. Other styles of parsnips should not be packed without directions from a laboratory connected with the canning industry. Cans of parsnips packed "asparagus style" should be processed on end.

(*b*) For processes for vacuum pack peas consult a laboratory connected with the canning industry.

Peas and Carrots

Can Name	Dimensions	Initial temperature	240° F.	Time at 245° F.	250° F.
		Deg. F.	*Min.*	*Min.*	*Min.*
No. 2 & smaller	307x409 & smaller	70	45	30	20
		140	40	25	18
No. 10	603x700	70	60	45	28
		140	55	40	25

Peppers or Pimientos, Green

Pressure processes adequate for sterilization render green peppers or green pimientos unmerchantable. It has been found necessary, therefore, to acidify these products to permit safe processing in boiling water and thereby ensure preservation without loss of merchantability. Acidification must be carefully controlled. For detailed procedures consult a laboratory connected with the canning industry.

Peppers or Pimientos, Red

Acidification of red peppers or red pimientos is desirable to prevent spoilage, even though it may not be necessary from the standpoint of public health. Acidification must be carefully controlled. For detailed procedures consult a laboratory connected with the canning industry.

Potatoes, sweet, solid pack (*a*) (*c*) (*e*)

Can Name	Dimensions	Initial temperature	Time at 240° F.
		Deg. F.	*Min.*
No. 1 Picnic	211x400	120	75
		150	65
		180	60
No. 2	307x409	120	105
		150	95
		180	85
No. 2½	401x411	120	120
		150	110
		180	95
No. 3 Cylinder	404x700	150	130
		180	115
		190	105

Potatoes, sweet, syrup pack, Eastern types, whole (*b*) (*c*)

Can Name	Dimensions	Put-in syrup strength	Initial temperature	Time at 240° F.	Time at 250° F.
		Deg. Brix	*Deg. F.*	*Min.*	*Min.*
No. 3 Squat & smaller	404x307 & smaller	25° or less	100	34	24
			140	32	22
			160	30	20
		Greater than 25°	100	53	33
			140	48	28
			160	45	25
No. 10	603x700	25° or less	100	50	32
			140	45	29
			160	43	27
		Greater than 25°	100	65	38
			140	55	32
			160	50	29

(*a*) For processes for asparagus style or vacuum pack sweetpotatoes, consult a laboratory connected with the canning industry.

(*b*) These processes apply to freshly dug Little Stem Jersey, Maryland Golden or similar varieties.

(*c*) It is emphasized that the sugar used in the canning of this product should comply with the bacterial standards for sugar formulated by the National Canners Association. See page 54. Under no circumstances should sugar in dry form be added to the cans.

(*e*) Processes for No. 10 cans considered necessary to safeguard against hazard to health result in a product of unmerchantable quality. It follows, therefore, that solid pack sweet potatoes should not be packed in cans larger than a No. 3 cylinder (404x700).

Potatoes, sweet, syrup pack, Porto Rico type (yams), whole, cut or sliced (*c*) (*d*)

Can Name	Dimensions	Initial temperature	Time at 240° F.	Time at 250° F.
		Deg. F.	*Min.*	*Min.*
No. 2	307x409	140	60	45
		160	55	40
No. 2½	401x411	140	65	50
No. 3 Squat	404x307	160	60	45
No. 10	603x700	140	80	65
		160	75	60

Potatoes, white, sliced or whole, in brine

Can Name	Dimensions	Initial temperature	Time at 240° F.	Time at 250° F.
		Deg. F.	*Min.*	*Min.*
No. 2	307x409	70	35	23
		140	30	20
No. 2½	401x411	70	40	30
		140	35	25
No. 10 (except sliced)	603x700	70	50	35
		140	45	30
No. 10 (sliced)	603x700	70	55	38
		140	50	32

(*c*) It is emphasized that the sugar used in the canning of this product should comply with the bacterial standards for sugar formulated by the National Canners Association. See page 54. Under no circumstances should sugar in dry form be added to the cans.

(*d*) These processes apply to the Porto Rico or similar varieties packed in a syrup having a put-in concentration of 50°Brix or less.

Pumpkin or Squash

Can Name	Dimensions	Initial temperature	Time at 240° F.	Time at 250° F.
		Deg. F.	*Min.*	*Min.*
No. 300	300x407	140	70	60
		160	65	55
		180	60	50
No. 2	307x409	140	85	70
		160	80	65
		180	75	60
No. 2½	401x411	140	115	100
		160	105	90
		180	95	75
No. 3 Cylinder	404x700	140	135	115
		160	125	105
		180	110	95
No. 10	603x700	140	235	205
		160	215	185
		180	190	165

Soups: *See* Specialties

Spinach or other greens

These cooks may not be adequate for continuous cookers, and canners planning to use a continuous cooker should consult a laboratory connected with the canning industry.

Drained weight and net weight are of determining importance with spinach and other greens and must be controlled to ensure that the retort process will carry the intended sterilizing efficiency. The maximum drained weight given cannot be safely exceeded, and the net weight of contents should be at least that given for the respective can sizes. For the minimum drained weights announced by the Food and Drug Administration, see page 56.

Since blanched spinach tends to become stratified horizontally in cans larger than the No. 2, it is found that heat penetration is more rapid when these cans are processed on their sides rather

Spinach or other greens (Continued)

than in a vertical position. Therefore the process is shorter for cans processed in a horizontal position.

Spinach or other greens, whole leaf

Can Name	Dimensions	Retort temperature	Initial temperature	Time	Maximum drained weight	Minimum net weight
		Deg. F.	*Deg. F.*	*Min.*	*Oz.*	*Oz.*
8Z Tall	211x304	252	100	40	6.25	7.75
			120	37		
			140	35		
No. 1 (Picnic)	211x400	252	100	40	8.0	10.0
			120	37		
			140	35		
No. 300	300x407	252	100	45	10.5	13.5
			120	43		
			140	40		
No. 303	303x406	252	100	50	11.7	15.2
			120	47		
			140	45		
No. 2	307x409	252	100	55	14.5	18
			120	53		
			140	50		
No. 2½ (horizontal position)	401x411	252	100	55	21	27
			120	53		
			140	50		
No. 2½ (vertical position)	401x411	252	100	65	21	27
			120	60		
			140	55		
No. 10 (horizontal position)	603x700	240	100	105	66	100
			120	100		
		252	100	65	66	100
			120	60		
No. 10 (vertical position)	603x700	240	100	140	66	100
			120	130		
		252	100	85	66	100
			120	75		

Spinach or Other Greens, cut (*a*)

Can Name	Dimensions	Initial temperature	Time at 240° F.	Time at 252° F.	Maximum drained weight	Minimum net weight
		Deg. F.	*Min.*	*Min.*	*Oz.*	*Oz.*
8Z Tall	211x304	100	60	45	6.25	7.75
		140	55	40		
No. 1 (Picnic)	211x400	100	60	45	8	10
		140	55	40		
No. 303	303x406	100	80	60	11.7	15.2
		120	75	55		
		140	75	55		
		160	65	50		
No. 2	307x409	100	90	70	14.5	18
		120	85	65		
		140	80	60		
		160	75	55		
No. 2½	401x411	100	105	80	21	27
		120	100	75		
		140	95	70		
		160	90	65		
No. 10	603x700	100	120	95	66	100
		120	115	90		
		140	105	80		
		160	100	70		

Squash: *See* Pumpkin or Squash

Succotash: *See* Corn, cream style

Sweetpotatoes: *See* Potatoes, sweet

Swiss chard: *See* Spinach

Turnips

Can Name	Dimensions	Initial temperature	Time at 240° F.
		Deg. F.	*Min.*
No. 2½ & smaller	401x411 & smaller	70	34
		140	30
No. 10	603x700	70	45
		140	40

Turnip tops: *See* Spinach

(*a*) These processes are to be used for ¼-inch to ½-inch cuts only. For processes to be applied to smaller or larger cuts, consult a laboratory connected with the canning industry.

Vegetables, chopped (*a*)

Product	Dimensions	Initial temperature	Time at 240° F.
		Deg. F.	*Min.*
Beans, green	211x210	120	60
	211x214	140	58
		160	55
Beets	211x210	120	45
	211x214	140	43
		160	40
Carrots	211x210	120	45
	211x214	140	43
		160	40
Spinach	211x210	120	65
	211x214	140	63
		160	60

Vegetable juices: *See* Specialties
Vegetable salad or mixed vegetables: *See* Specialties
Vegetable soup: *See* Specialties

Vegetables, strained (*b*)

Product	Can Name	Dimensions	Initial temperature	Time at 240° F.
			Deg. F.	*Min.*
Asparagus	Baby food	202x214	120	42
			140	40
			160	38
	No. 2	307x409	140	85
			160	80
			180	75
Beans, green	Baby food	202x214	120	42
			140	40
			160	38
	No. 2	307x409	140	85
			160	80
			180	75
Beans, lima	Baby food	202x214	120	53
			140	50
			160	47
	No. 2	307x409	140	105
			160	100
			180	90

Continued on page 41

(*a*) For strained vegetables packed in 211x210 or 211x214 cans, see processes for "Vegetables, strained".

(*b*) It should be emphasized that the above processes for No. 2 cans will result in a finished product somewhat below the quality obtained heretofore with shorter processes used for the standard baby food cans.

Vegetables, strained (*a*) (Continued)

Product	Can Name	Dimensions	Initial temperature	Time at 240° F.
			Deg. F.	*Min.*
Beets	Baby food	202x214	120	42
			140	40
			160	38
	No. 2	307x409	140	90
			160	85
			180	75
Carrots	Baby food	202x214	120	42
			140	40
			160	38
	No. 2	307x409	140	90
			160	85
			180	75
Peas	Baby food	202x214	120	53
			140	50
			160	47
	No. 2	307x409	140	105
			160	100
			180	90
Potatoes, Sweet	Baby food	202x214	120	47
			140	45
			160	43
	_____	211x210	120	58
	_____	211x214	140	55
			160	52
Spinach	Baby food	202x214	120	47
			140	45
			160	43
	No. 2	307x409	140	85
			160	80
			180	75
Squash	Baby food	202x214	120	42
			140	40
			160	38
	_____	211x210	120	53
	_____	211x214	140	50
			160	47

(*a*) It should be emphasized that the above processes for No. 2 cans will result in a finished product somewhat below the quality obtained heretofore with shorter processes used for the standard baby food cans.

II.—RIPE OLIVES (*a*)

Whole, with or without pits, in brine

Can Name	Dimensions	Initial temperature	Time at 240° F.	Time at 250° F.
		Deg. F.	*Min.*	*Min.*
No. 10 & smaller	603x700 & smaller	70–160	60	50

III.—SPECIALTIES

This is a group of products which vary widely from each other in composition and which from the standpoint of processing have little in common with the standard fruits and vegetables. Specialties may be vegetable products, fish products or meat products, or combinations thereof. Specialties not only differ from each other, but each individual specialty as prepared in different canning plants is likely to vary in composition and in canning procedure from the same product prepared by another maker. Because of this difference in formula and the variation in canning procedure by which they are prepared, specialties should not be canned without directions from a laboratory connected with the canning industry.

IV.—MEAT OR MEAT PRODUCTS

Due to variations in formula and methods of procedure which may affect process relationships, these products should not be packed without directions from a laboratory connected with the canning industry.

V.—CHICKEN OR CHICKEN PRODUCTS

Due to variations in formula and methods of procedure which may affect process relationships, these products should not be packed without directions from a laboratory connected with the canning industry.

(*a*) For processing minced, crushed, chopped, or sliced olives, a laboratory connected with the canning industry should be consulted, as the size of particles, tightness of pack, and moisture content must be considered before the process is recommended.

VI.—MARINE PRODUCTS (*a*)

Clams or Clam chowder (*b*)

Crab meat, Blue or Gulf, hand-picked, in brine (*c*)

Can Name	Dimensions	Initial temperature	230° F.	Time at 240° F.	250° F.
		Deg. F.	*Min.*	*Min.*	*Min.*
½ Tuna (No liner)	307x113 (*e*)	70	70	35	20
½ Tuna (One piece liner)	307x113 (*e*)	70	80	50	35

Crab meat, Blue or Gulf, hand-picked, vacuum pack (*c*) (*d*)

Can Name	Dimensions	Initial temperature	230° F.	Time at 240° F.	250° F.
		Deg. F.	*Min.*	*Min.*	*Min.*
½ Tuna (No liner)	307x113 (*e*)	70	80	45	35
½ Tuna (One piece liner)	307x113 (*e*)	70	85	50	35
———— (No liner)	307x208 (*f*)	70	85	55	40
———— (One piece liner)	307x208 (*f*)	70	95	60	45

Crab meat, Dungeness (*a*)

Fish flakes (*a*)

Herring and herring roe (*a*)

(*a*) For processes for smoked, kippered or specially treated seafoods, consult a laboratory connected with the canning industry.

(*b*) Due to variation in raw product and lack of standardized packing procedure, this product should not be packed without directions from a laboratory connected with the canning industry.

(*c*) Processes for mechanically-picked crab meat should be obtained from a laboratory connected with the canning industry.

(*d*) The processes given for vacuum pack crab meat are dependent on (1) The maintenance of at least 26 inches of can vacuum immediately before processing; (2) the presence of ½ to 1 ounce of free liquid; (3) the use of a fill-in weight which will result in a drained weight not greater than the maximum specified in the applicable footnotes.

(*e*) Process times suggested for maximum drained weight of 5.25 ounces.

(*f*) Process times suggested for maximum drained weight of 7.75 ounces.

Lobster (*a*)

Mackerel, in brine

Can Name	Dimensions	Initial temperature	Time at 240° F.	Time at 250° F.
		Deg. F.	*Min.*	*Min.*
8Z Tall	211x304	70	75	60
		130	70	50
No. 300	300x407	70	90	75
		130	80	65

Oysters, Cove, Atlantic and Gulf Coast

Can Name	Dimensions	Initial temperature	Time at 240° F.	Time at 250° F.
		Deg. F.	*Min.*	*Min.*
No. 1 (Picnic) & smaller	211x400 & smaller	70	24	14
		130	23	13
No. 95	307x400	70	28	14
No. 2	307x409	130	27	13

Oysters, Pacific Coast

Can Name	Dimensions	Initial temperature	Time at 240° F.
		Deg. F.	*Min.*
No. 1 Tall & Smaller	301x411 & smaller	70	43
		130	40

Salmon

Can Name	Dimensions	Initial temperature	Time at 240° F.	Time at 245° F.	Cool Method
		Deg. F.	*Min.*	*Min.*	
¼ Flat	301x106	60	50	40	water
		60	45	35	air
½ Flat	307x201.25	60	75	65	water
		60	70	60	air
No. 1 Tall	301x411	60	100	90	water
		60	90	80	air

(*a*) Due to variation in raw product and style of pack and to lack of standardized packing procedure, this product should not be packed without directions from a laboratory connected with the canning industry.

Sardines, (*a*)

Shrimp, wet pack

Can Name	Dimensions	Initial temperature	Time at 240 F.	Time at 250 F.
		Deg. F.	*Min.*	*Min.*
No. 1 (Picnic) or smaller	211x400 or smaller	70	26	14
		90	25	13
		120	24	12
———	307x208	70	27	15
No. 95	307x400	90	25	13
		120	24	12
No. 5	502x510	70	30	19
		90	27	16
		120	26	15

Shrimp, dry pack

Can Name	Dimensions	Initial temperature	Time at 240° F.	Time at 250° F.
		Deg. F.	*Min.*	*Min.*
No. 1 (Picnic)....(One piece liner)..	211x400	70	80	60
No. 1 (Picnic)....(No liner).....	211x400	70	70	50
———.....(No liner).....	307x208			
No. 95.....(No liner).....	307x400	70	75	55

Tuna, all styles, in oil

Can Name	Dimensions	Initial temperature	Time at 240° F.	Time at 250° F.
		Deg. F.	*Min.*	*Min.*
¼ Tuna	211x109	70	65	40
½ Tuna	307x113	70	75	55
No. 1 Tuna	401x206	70	95	80
4 Lb. Tuna	603x408	70	230	190

(*a*) Due to variation in raw product and style of pack and to lack of standardized packing procedure, this product should not be packed without directions from a laboratory connected with the canning industry.

APPENDIX

PRECAUTIONS FOR HANDLING FILLED CANS

The installation of many of the newer labor saving devices for handling filled cans has introduced certain hazards which, if not minimized, may result in some spoilage with the best possible double-seam construction. Before the cans are thoroughly cooled, the seams are slightly expanded and the compound lining is somewhat soft or plastic. In addition to the usual attention to good seam construction, precautions must be taken in handling the cans before they are thoroughly cooled to prevent even small dents on, or near, the double-seams. This involves elimination of fast runways with sharp turns and abrupt stops for handling filled cans both before and after processing. Care should also be taken to avoid conditions which would strain the seams during the processing or cooling; e.g., excessive holding time of unprocessed cans, inadequate exhausting or too rapid release of pressure during cooling. In cooling under pressure, particular attention must be paid to the magnitude of the pressure and the length of time it is maintained since the greater the differential pressure between the inside and the outside of the can, the greater the tendency toward forcing minute quantities of the cooling water into the can during this critical period. Bacterial content of cooling water should be kept as low as possible since the spoilage hazard is reduced in proportion to the number of microorganisms present.

GENERAL SOURCES AND CONTROL OF SPOILAGE CONTAMINATION

The efficiency of any process depends in large measure upon the type and number of microorganisms in the product at the time of canning. In general, the processes presented in this bulletin are regarded as adequate when something greater than an average number of spoilage organisms is present. They are not necessarily adequate in cases of extreme contamination by spoilage bacteria that may or may not be associated with insanitary conditions. Control of contamination by applying the strict principles of sanitation and by other appropriate means, with adequate, organized supervision, inspection and responsibility is a necessary adjunct to any process.

Factory surveys to determine the identity of contamination sources and to develop means for their elimination have been conducted since 1926. The surveys have shown that the important sources of significant contamination with heat resistant spoilage organisms are located within the canning plant. Spoilage organisms come originally from the soil and are brought to the canning plant on the raw product. Preliminary washing operations are sufficient, with most products, to reduce this initial soil-borne contamination to a level which will not result in spoilage. However, residual spoilage types may seed the canning equipment and increase in numbers to a degree such that they constitute a spoilage hazard. There are exceptions, notably in the case of asparagus and mushrooms where soil-borne contamination of the raw product may be a direct cause of spoilage.

Factory studies to date have centered chiefly upon the canning of asparagus, corn, mushrooms, peas, pumpkin, and spinach, but facts developed in these studies are applicable to other products. Accordingly, use of the following information should serve to control contamination to a degree that will ensure the effectiveness of the processes presented in this bulletin.

Wooden equipment

In general, the use of wood in canning equipment is not recommended, because bacteria may become seeded in the pores and once established may contaminate food materials to such an extent that spoilage occurs with a process that has been satisfactory for years. Any wooden equipment with which food materials may come in contact, such as brine and hot water tanks, conveyors, blanchers, canning tables and even such small items as paddles and rollers, may act as carriers of contamination. For example, wooden tanks used for storage of hot water for general plant purposes may contaminate a whole canning system. Wooden brine tanks, at the beginning of a day's run, may supply large numbers of organisms to the product being canned. Owing to dilution their number decreases markedly during steady operation, only to build up again during a shutdown. Wood, being porous, is able to retain bacteria and hold them mechanically immune from scrubbing and other cleaning processes. "Seeding" may be prevented to a considerable degree by constant cleaning, but in spite of all that may be done, there is at present no practical treatment which will rid wood of organisms that are established in it.

Pumps, pipes, extractors, cyclones, etc.

Pumps, pipes, extractors, cyclones, etc., should be selected from the standpoint of ease in cleaning, because such equipment may hold food material that will serve as a medium for bacterial growth and permit the development of sufficient organisms to contaminate seriously the first part of the next day's pack. All such equipment should be thoroughly cleaned after being used, then thoroughly cooled with water and kept cool until next operated. It should likewise be flushed again with water immediately before it is used.

Care should be taken during the cleaning operation to blow steam through the perforations of steam distribution pipes which are submerged in food or brine during operation and to ensure that all perforations are open. Circulating "feeder" pipes should be thoroughly cleaned at the close of the day's pack. Preferably, they should be so constructed that they may be dismantled and cleaned with brushes. "Dead ends" should be eliminated or provided with drains so that they may be thoroughly flushed at frequent intervals. Pumps should be dismantled during the clean-up operation and only pumps which are adapted to daily cleaning should be used. Some person should be delegated to inspect all cleaning operations to ensure that this work is efficiently done.

Fluming

Flumes, such as those used for conveying peas and whole grain corn, may become sources of bacterial contamination. In particular, the use of water at temperatures in the range of 100°F. to 180°F. should be avoided since this may provide a favorable condition for the growth of thermophilic spoilage bacteria. The reuse of flume water when hot may aggravate the contamination. It is advisable to use only cold water for fluming purposes.

Fillers

Filling machines used with low-acid products have been found to be contaminated with spoilage bacteria. This contamination is usually the result of the filler being maintained at temperatures within the thermophilic growth range. This might occur during operation from contact with a heated product or during shutdown periods from leakage of steam supply valves.

Fillers should be dismantled and cleaned as frequently as practicable. After the day's clean-up, the fillers should be flushed with cold water with all machinery in motion to chill the equipment, and the fillers should be left clean, cold, and empty during

the overnight shutdown. If the filler operates at temperatures within the thermophilic range during actual packing operations, it should be emptied of its product every 4 hours and thoroughly flushed with water with all machinery kept in motion.

Canning ingredients

In recent years there has been a growing appreciation of the importance, as carriers of spoilage contamination, of certain ingredients commonly used in canning. Among these are sugar, starch, flour, and dried milk. Bacterial standards for sugar and starch are discussed on page 54.

SPECIFIC SOURCES OF SPOILAGE CONTAMINATION

In addition to the preceding general information on sources of contamination, canners of certain products upon which extensive investigations have been made will find the following additional information and suggestions of value.

Corn

Preheating Systems, Mixing and Blending Tanks. The increasing use of mixing and blending equipment in which corn is handled while hot has demonstrated further need for contamination control. Such equipment while hot (180°F. or higher) does not act as breeding points for spoilage bacteria, but when in the range 100°F. to 180°F. there is opportunity for development of thermophilic organisms. Usually this development occurs overnight and during shutdowns, and the spores which develop during those times serve subsequently to contaminate the run. As a rule, it is best to hold the tanks empty over-night. However, there appears to be no objection to holding them full of cold water provided care is taken to ensure that there are no leaky valves in the line which might tend to warm the equipment. Care should be taken during the cleaning operation to blow out perforated steam supply pipes; otherwise they may hold food material that will serve as a bacterial medium. Flushing and cooling may be accomplished conveniently by tapping a cold water line into the steam supply line adjacent to the mixer and blending tank.

Circulating Systems. Such systems represent another step in complexity from the preheating systems. The circulating feeder pipes should be thoroughly cleaned at night and preferably they should be so constructed that they may be dismantled and cleaned with brushes.

Whole Kernel Corn. With this product special care should be taken to prevent contact with wood equipment and, after being cut, the corn should be subjected to an efficient wash. The use of warm water or hot water in flotation washers should be avoided since such practice may lead to the rapid development of spoilage bacteria. Failure to wash the cut corn properly may result in spoilage.

Peas

The recommendations made with respect to control of blancher contamination in the canning of peas apply also to other products that are blanched in a conventional pea blancher such as lima beans and green and wax beans.

Blanchers. Both rotary drum blanchers and tubular blancher systems may become contaminated with thermophilic spoilage bacteria. The contamination which occurs during shut-down periods can be minimized by prompt cooling of the blanchers after use, by thorough cleaning, elimination of steam leaks, and flushing of the blancher system before its next use. However, thermophilic contamination may also occur during operation of either type of blancher system.

In rotary drum blanchers the contaminating bacteria are able to grow on the inner surfaces, above the water line, where temperatures are reduced by cool air drawn into the blanchers under loose-fitting doors and other openings. Any surface in the blancher where the temperature ranges between 100°F. and 180°F. can be the site of bacterial growth from which heat-resistant spores will be washed by condensate into the blanch water, and there contaminate the peas.

Efforts to prevent contamination in rotary drum blanchers should be directed toward elevating inner surface temperatures above 180°F. Blancher doors should be closed and fastened at all times. Doors which are bent or otherwise out of shape should be repaired in order to exclude as much cool air as possible. Vent stacks should be eliminated from the shell of the blancher. The coldest sections within a drum blancher are at the feed end. The use of a spray or steam jet, inserted at the upper edge of the feed end, which delivers steam or hot water (190°F. or higher) over the inside surfaces has been found useful in preventing contamination. During operation the temperature of the blanch water should be as high as practicable (at least 180°F.) and the reels should be kept in motion continuously while the blanchers are being heated or

being held at operating temperature. A continuous overflow from the blancher should be maintained during operation.

The blancher water should be dumped as often as practicable since the number of bacterial spores in the water increases with time and use. The drain and water supply pipes should be of sufficient size to permit rapid draining and re-filling.

In tubular blanching systems a large percentage of the flat sour spore contamination occurs in the de-watering reel into which the peas are discharged from the blanchers. Thermophilic bacteria grow on the mesh of the screen and on the surfaces of the splash boards around the reel and the pan underneath. Spores produced by the bacteria are added to the peas as they pass through the reel or may be washed into the water and re-circulated in the blancher. This contamination can be reduced if sprays are installed to wash the surface of the reel with water which is preferably, but not necessarily, chlorinated. The use of cold water for this purpose is desirable to lower the temperature of the peas before they enter the quality grader. Sprays should also wash down the inner surfaces of the splash boards or canopy surrounding the reel. Tests have indicated that cold water is effective in reducing flat sour contamination when used in these sprays. The foam which accumulates on tanks supplying recovered water to tubular blanchers can be the growth site for thermophilic spoilage bacteria. A large, broad overflow should skim the surface of the tank. Top sprays delivering streams of water at a flat angle will help prevent the formation of foam and aid in skimming the tank.

It is important the peas be washed thoroughly after blanching. Adequate washing will remove large numbers of spoilage bacteria but cannot be depended upon to remove all of the bacteria added by a heavy contamination. Washing with cold water will reduce the temperature of the peas and thus help to minimize slime growth in subsequent equipment and prevent undesirable temperature increases in the quality grader brine.

Pumpkin

Practice in pumpkin canning is not standardized and the following suggestions are based upon a study of systems used by a majority of the pumpkin canners. Consideration of sources of contamination in pumpkin canning begins with the wilting equipment.

Wooden Box or Tower Wilters. As already noted, wooden equipment is objectionable, but it may be lined with metal if this is practicable.

Continuous Metal or Wooden Box Wilters. Both metal and wood boxes used as continuous wilters may be sources of contamination. They are difficult to clean and cool.

Continuous Conveyor Presses. There are various modifications in this type of equipment but the same principle is involved, that is, the pumpkin from the wilter is dropped into a hopper and carried between two moving belts. The distance between the belts gradually decreases toward the outlet end, and the pressure that is exerted squeezes the juice from the pumpkin. These presses are complicated mechanically and the parts vary in temperature. Where the temperature is favorable to thermophilic growth there may be some bacterial development. Some measure of control may be exerted by spraying the press "apron" with cold water, but this expedient is not fully satisfactory. From the viewpoint of contamination control the screw type press is much to be preferred. In this equipment the pumpkin is "wormed" through a tapering perforated screen. During operation, the temperature of all parts is so high (180°F. to 200°F.) that no growth is possible. The screw press is readily accessible for cleaning.

Concentration of Pumpkin Juice. It is usual to discard the juice from the press, but in some cases it is the practice to concentrate this juice and add it to the pumpkin at the finisher. This system is satisfactory when the general packing procedure is such as to keep contamination at a low level. However, the concentration of contamination is increased as the volume of juice is reduced by evaporation, and such contamination as may be present is returned to the product when the juice is not discarded.

Spinach

Washers. Spinach washers include "immersion," "spray-rotary" and "spray-belt" types. They are used singly, in multiple, and in various combinations. Their primary function is to remove grit and adhering soil and concurrently the soil-borne bacteria which are present. In all types of equipment, the washing efficiency is determined, at least in part, by the amount of water used. Thorough washing is of primary importance and a large volume of water is required. Washers should not be overloaded because this reduces their efficiency. When both immersion and spray types are used in the same line, better results are achieved if the immersion washer is placed before the spray washer. The first washing should always be done with cold water. The use of warm water in the first wash may lead to increase of bacteria that come from

the field with the spinach, thus contaminating the equipment. Water should not be re-circulated where a single washer is used.

BLANCHERS. Blanching equipment may be a source of spoilage bacteria, particularly those of the thermophilic group. To minimize the hazards of spoilage from this source, the washing and cooling treatments previously discussed should be applied. Occasionally rotary drum pea blanchers have been used, but as this type of equipment is difficult to clean there is opportunity for the development of spoilage organisms, resulting in continuous contamination of the spinach. Spoilage has been traced to such a blancher and its use is therefore not recommended. The blanch water should be renewed at a reasonably rapid rate.

SIGNIFICANCE OF SUGAR AND STARCH CONTAMINATION

Sugar, both beet and cane in dry or liquid form, may carry spores of all three groups of thermophilic bacteria that are important as spoilage agents in low-acid canned foods. The sugar industry is aware of this condition and has taken steps to control thermophilic contamination in its products. In 1931 the National Canners Association formulated and published bacterial standards for sugar as a basis for its judgment regarding the suitability of sugar to be used in canning low-acid products. These standards have been applied by control laboratories connected with the canning industry, by the sugar industry, by Federal and State laboratories, etc. That part of the published statement referring to standards reads as follows:

TOTAL THERMOPHILIC SPORE COUNT: For the five samples examined, there shall be a maximum of not more than 150 spores and an average of not more than 125 spores per 10 grams of sugar.

FLAT SOUR SPORES: For the five samples examined, there shall be a maximum of not more than 75 spores and an average of not more than 50 spores per 10 grams of sugar.

THERMOPHILIC ANAEROBIC SPORES: These shall be present in not more than three of the five samples and in any one sample to the extent of not more than four of six tubes inoculated by the standard procedure.

SULFIDE SPOILAGE SPORES: These shall be present in not more than two of the five samples and in any one sample to the extent of not more than five spores per 10 grams.

Sugar that is certified as suitable for canning low-acid vegetables is produced by large manufacturers of both beet and cane sugar. It is recommended that canners of low-acid products specify that such sugar be provided, and it is suggested as an added safeguard that samples of delivery be submitted from time to time to a labora-

tory connected with the canning industry to determine whether deliveries conform to specifications. In collecting dry sugar samples, five individual 1/2 pound quantities should be taken from each of five bags or other containers of the shipment or lot in question. These samples should be sent to the laboratory in clean, sealed containers. If samples from more than one shipment or lot are submitted each container should be appropriately marked to distinguish the lot of its origin.

It is appreciated that the adequacy of this sampling will vary in relation to the size of the shipment or lot, but it is felt that where there is any significant variability in the shipment this fact will become evident in the majority of cases through individual tests on five samples.

For sampling liquid sugar, three individual samples of approximately 6 ounces each should be drawn from the tank or pumping line. The first sample should be taken at the beginning of the pumping operation, the second at the mid-point, and the third near the end of the pumping. Each sample should be sealed and marked with its number and the designation of the lot of its origin.

The significance of starch contamination has also been demonstrated and starch to be used in the canning of low-acid products should be purchased on specification. The standards for sugar contamination may also be applied to starch and other cereal ingredients, and periodic laboratory checks are desirable.

Minimum Drained Weights

Mushrooms

A maximum drained weight for each can size is specified in the process table which appears on page 32. It is desired here to emphasize again the importance of not exceeding this maximum drained weight. At the same time, it is necessary that the fill of container comply with the Standard of Fill of Container issued by the Food and Drug Administration. The minimum drained weight of mushrooms, in ounces, as contained in the Standard, is listed below for each can size for which processes are suggested:

Can name	Dimensions	Minimum drained weight *Ozs.*
2Z Mushroom	202x204	2.0
4Z Mushroom	211x212	4.0
8Z Mushroom	300x400	8.0
Jumbo	307x510	16.0
No. 10	603x700	68.0

Spinach

In the processes for spinach suggested on pages 38 and 39 a maximum drained weight of spinach and minimum net weight of the entire contents of the can are suggested for each size of can. It is desired here to emphasize again the importance of not exceeding this maximum drained weight and of securing at least the minimum net weight. At the same time it is, of course, important here, as elsewhere, to avoid slack fill. The Food and Drug Administration has announced that the weight of drained spinach should be at least 13.0, 19.0, and 60.0 ounces, respectively, in No. 2, No. 2½, and No. 10 cans. It is also stated by the Food and Drug Administration that a can of any other size should have a drained weight proportional to the weight stated above for the nearest size of can. Corresponding weights for other sizes of cans for which processes are given in this bulletin are shown in the tabular statement given below:

Can Name	Dimensions	Minimum drained weight
		Ozs.
8Z Tall	211x304	5.5
No. 1 (Picnic)	211x400	7.0
No. 300	300x407	9.7
No. 303	303x406	10.7
No. 2	307x409	13.0
No. 2½	401x411	19.0
No. 10	603x700	60.0

DAILY PROCESS RECORD CARD

Plant Location _____ Date _____ 19 _____

Product	Temp. chart No.	Batch	Retort No.	Size can	No. cans	Code	Time in	Time up	Time out	Cook min.	Thermometers			Gauge pressure
											Mercury		Chart	
											No. 1	No. 2		

IMPORTANT POINTS FOR RETORT OPERATORS

1. Read carefully the entire introduction to NCA Bulletin 26-L in order that you may understand the significance of the tasks you perform.
2. Don't allow crates of cans to stand around before processing. Spoilage may result. See page 15.
3. Don't trust your memory on processes. Consult Bulletin 26-L.
4. Keep retort instruments and valves in good working order. Instruments need periodic testing.
5. Vent retorts thoroughly. Don't start timing process until temperature is up and pressure gauge and thermometer agree. See page 17.
6. Timing the process is only part of the job. Keep the retort temperature correct.
7. Keep permanent time and temperature records of every retort load processed. See opposite page.
8. Cool cans properly. Too little cooling may cause either stackburn or spoilage; too much may cause rusting.

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